The program ‘heatequation.py’ uses the Crank-Nicolson method to solve the heat diffusion problem in a rod where the two ends of the rod are insulated and subject to given boundary conditions. In the figure below (taken from *Elementary Differential Equations and Boundary Value Problems* by Boyce, DiPrima, and Meade), u(x,t) represents the temperature of the bar at location x along the bar and time t in the simulation.

A blue tube with a dotted line

Description automatically generated

The output of the program is a plot of x against u(x,t), for several timesteps within the simulation. This will graphically show the temperature distribution in the bar at several points in time.

The program accepts these inputs, which determine the initial parameters for the simulation:

L: length of rod  
T: total simulation time  
dx: step size along x-axis  
dt: step size along t-axis  
cond0: x=0 boundary condition  
condL: x=L boundary condition  
bc: string, specifies type of boundary condition  
alpha2: thermal diffusivity of the rod ()

First, I simulate with a set of arbitrary, “standard” values for the parameters. These are: L = 1.0, T = 0.1 , dx = 0.1, dt = 0.025, cond0 = 0, condL = 0, bc, 'dirichlet', alpha2 = 1.0.

A graph of a line graph

Description automatically generated with medium confidence

Then, I experiment on the same standard rod with varying alpha-squared values. These values are taken from the following table in *Elementary Differential Equations and Boundary Value Problems.*

A table with numbers and symbols

Description automatically generated

Silver:

A graph of a line graph

Description automatically generated with medium confidence

Air:

A graph of a line graph

Description automatically generated

Water:

A graph of a line

Description automatically generated

Now I alter the rod length from 1.0m.

L = 2.0

A graph of a temperature

Description automatically generated with medium confidence

L = 4.0

A graph of a function

Description automatically generated with medium confidence

L = 10.0

A graph of a diagram

Description automatically generated with medium confidence

What if I vary the Dirichlet boundary conditions?

A graph of a line graph

Description automatically generated

A graph of a temperature

Description automatically generated with medium confidence

A graph of a temperature

Description automatically generated with medium confidence

Now, we try some neumann boundary conditions.

A graph of a line graph

Description automatically generated with medium confidence

A graph of a line graph

Description automatically generated with medium confidence

A graph of a line graph

Description automatically generated with medium confidence